Available online at www.sciencedirect.com
SCIENCE DIRECT®
Postharvest Biology and Technology 32 (2004) 99–107
Postharvest Biology and Technology
www.elsevier.com/locate/postharvbio

Effect of package film on the quality of fresh-cut salad savoy

Ji Gang Kim[a,b], Yaguang Luo[a,*], Kenneth C. Gross[a]

[a] *Produce Quality and Safety Laboratory, USDA, ARS, Henry A. Wallace Beltsville Agricultural Research Center. Bldg. 002, 10300 Baltimore Avenue, Beltsville, MD 20705-2350, USA*
[b] *National Horticultural Research Institute, 475 Imok-Dong, Jangan-Gu, Suwon 440-706, Republic of Korea*

Received 2 September 2002; accepted 10 October 2003

Abstract

Salad savoy (*Brassica oleracea* L.) is a vegetable crop that is becoming a valued addition to fresh-cut salad mixes. This study was conducted to develop a modified atmosphere packaging system for fresh-cut salad savoy and to evaluate the effect of film oxygen transmission rate (OTR) on package atmospheres, and consequently product quality changes during storage. Two varieties of salad savoy (white and violet) were cut into approximately 5 cm × 5 cm slices and sanitized in 100 μl l^{-1} chlorine solution. The products (85 g each) were packaged in sealed 19 cm × 22 cm polyethylene bags prepared with films of selected OTRs at 8.0, 16.6, 21.4, and 29.5 pmol s^{-1} m^{-2} Pa^{-1} and stored at 5°C for 25 days. Evaluation parameters included package atmospheres, product respiration rate, color, cut-end discoloration (browning), off-odor, decay, and overall quality. Results indicated that the OTR of the package film significantly ($P < 0.05$) affected package atmospheres, product quality, and shelf-life, under the tested package configuration and storage condition. Packages with 16.6 and 21.4 OTR films attained the desired O_2 (1.4–3.8 kPa) and CO_2 levels (3.6–6.3 kPa) on day 10 and throughout the storage period; products stored in these packages maintained freshness with high overall quality scores. Packages with 8.0 OTR film exhibited a rapid depletion of O_2 (to ∼0 kPa) and accumulation of CO_2 (11.0–12.6 kPa), resulting in off-odor, decay and unacceptable quality of the products at the end of storage. Samples from packages prepared with 29.5 OTR film developed discoloration on the cut-ends due to high O_2 (6.0–7.9 kPa) in the packages. White salad savoy had higher respiration rates and lower quality scores than violet salad savoy. Overall, both white and violet salad savoy maintained good quality and shelf-life throughout the 25-days storage period under the most favorable atmosphere condition.
Published by Elsevier B.V.

Keywords: Gas composition; Minimally processed; Modified atmosphere packaging (MAP); Oxygen transmission rate; Postharvest technology; Salad savoy; Shelf-life

1. Introduction

Salad savoy is a new vegetable crop of the *crucifer* family, and is the result of breeding kale (*Brassica oleracea*L. var. *acephala*) and cabbage (*Brassica oleracea*L. var. *capitata*) (Salad Savoy Corp., 2002). Salad savoy, also known as colored varieties of kale, are typically used as decorative garnishes, but are as edible as the more common kale variety (Sugar, 1999). The consumption of salad savoy has increased over the past decade and is becoming a valued addition to fresh-cut salad mixes. The preparation of

* Corresponding author. Tel.: +1-301-504-6186; fax: +1-301-504-5107.
E-mail address: luoy@ba.ars.usda.gov (Y. Luo).

0925-5214/$ – see front matter Published by Elsevier B.V.
doi:10.1016/j.postharvbio.2003.10.006

fresh-cut products causes damage to plant tissues, rendering a more perishable product with shortened shelf-life, compared to intact fruits and vegetables (Guerzoni et al., 1996; Watada et al., 1996). This problem is primarily due to a higher respiration rate and the significant damage resulting from cutting (Pirovani et al., 1997). Fresh-cut processing affects quality factors such as appearance, flavor, and color, and product deterioration may proceed rapidly. Modified atmosphere packaging (MAP) is effective in prolonging the shelf-life of horticultural commodities by decreasing oxygen (O_2) and increasing carbon dioxide (CO_2) concentrations in the package atmosphere achieved via the interaction between respiratory O_2 uptake and CO_2 evolution of packaged produce, and gas transfer from the package films (Jacxsens et al., 1999; Makino, 2001; Schlimme and Rooney, 1994). In general, major factors affect the equilibrium gas concentrations of packaged produce include packaged product weight and its respiration rate, package film oxygen/carbon dioxide transmission rate and the respiring surface area (Bell, 1996), and storage temperature. However, for packaged fresh-cut vegetables in the retail market, package surface area and product fill weight are often pre-determined to certain degree to achieve a market appeal, and the respiration rate is also influenced by numerous factors, including storage temperature, cut size and vegetables types etc. Therefore, selecting package films with suitable OTRs plays an important role in developing MA packages for improved quality and shelf-life of fresh-cut produce.

Although the consumption of fresh-cut salad savoy has increased in the past decade, little information exists on its quality maintenance. The objectives of this study were to develop a MAP for fresh-cut salad savoy and to evaluate the influence of various package film OTR on package atmospheres and consequently product quality and shelf-life.

2. Materials and methods

2.1. Processing and packaging

White and violet varieties of salad savoy (*Brassica oleracea* L.) were harvested in Yuma, AR. The products were hydro-cooled immediately, shipped overnight at 5 °C to our laboratory at Beltsville, MD, and processed within 2 days of harvest. Fresh salad savoy leaves were cut into approximately 5 cm × 5 cm slices, washed in 100 $\mu l\,l^{-1}$ chlorine solution (NaOCl) for 1 min, and centrifuged to remove excess water using a salad centrifugal dryer (Model T-304, Meyer Machine Co., TX). Fresh-cut salad savoy samples (85 g each) were packaged in sealed 19 cm × 22 cm bags prepared with polyethylene films with selected OTRs at 8.0, 16.6, 21.4, and 29.5 pmol $s^{-1}\,m^{-2}\,Pa^{-1}$ and stored at 5 °C for 25 days. The film OTR was determined by the film manufacturer (Packaging Concept Inc., Salinas, CA) at 23 °C, 1 ATM using a MOCON apparatus according to an ASTM procedure (ASTM, 1986). At 5 °C, the film OTRs were 3.1, 4.7, 6.8 and 11.9 pmol $s^{-1}\,m^{-2}\,Pa^{-1}$, determined following a procedure from Moyls et al. (1992). Test data obtained from this procedure have been previously shown to compare well with the average values obtained from a MOCON apparatus (Moyls et al., 1992).

2.2. Respiration rate and gas composition

Both intact and fresh-cut salad savoy samples (200 g each) were placed in gas tight containers at 5° C. The containers were flushed with CO_2 scrubbed and humidified air at a flow rate of 20 ml s^{-1}. The rate of CO_2 production was measured for 24 h in a flow-through system with a gas chromatograph (HP 5890, Hewlett-Packard, MD) equipped with a Hayesep Q column (3 mm × 240 mm) and a thermal conductivity detector. Gas compositions (O_2 and CO_2) of fresh-cut salad savoy packages were measured using a gas analyzer (Model Combi Check 9800-1, PBI Dansensor Co., Denmark) by placing the needle directly into the packages.

2.3. Color

Ground color of fresh-cut salad savoy leaves was measured using a Minolta Chroma Meter (Model CR-300, Minolta Corp., Japan). The color values of L^*, a^*, and b^* were converted into hue angle [hue $= \tan^{-1}$ (b/a)], chroma [chroma $= (a^2 + b^2)^{0.5}$], and hue difference [Δhue $= (\Delta E^2 - \Delta L^2 - \Delta C^2)^{0.5}$] according to Nunes and Emond (1998) and Heimadal et al. (1995).

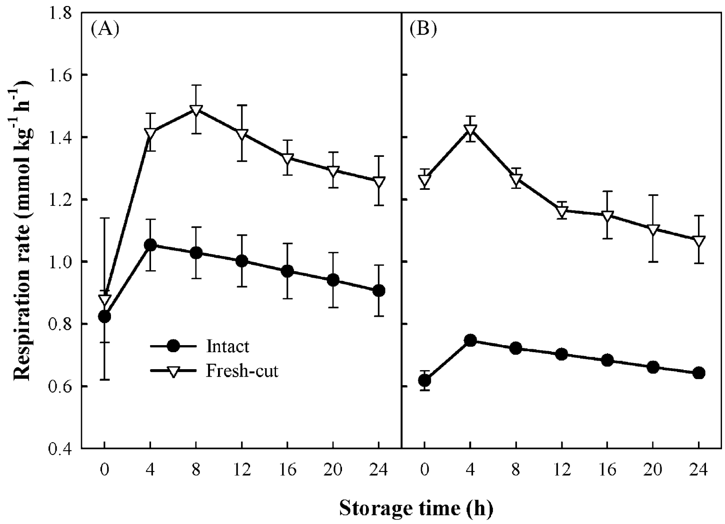

Fig. 1. Respiration rates of intact and fresh-cut salad savoy stored at 5 °C: (A) white salad savoy and (B) violet salad savoy. Vertical bars represent ±1 S.E.

2.4. Quality attributes

Sensory quality of fresh-cut salad savoy was evaluated by a three-member trained panel. Training was given to the panel members on how to recognize and scale the quality attributes of fresh-cut salad savoy. Prior to each evaluation, the panel members were given reference samples to calibrate the scales. The samples were coded with three-digit numbers to mask the treatment identity in an effort to minimize the test subjectivity and ensure test accuracy. Off-odor was evaluated immediately after opening the packages and scored on a 0–4 scale, where 0: none; 1: slight; 2: moderate; and 4: severe (Lopez-Galvez et al., 1997). Discoloration was scored on a 0– 4 scale, where 0: none; 1: slight; 2: moderate; and 4: severe. Decay was calculated by the weight of all pieces of salad savoy in each package showing any visible decay appearance, divided

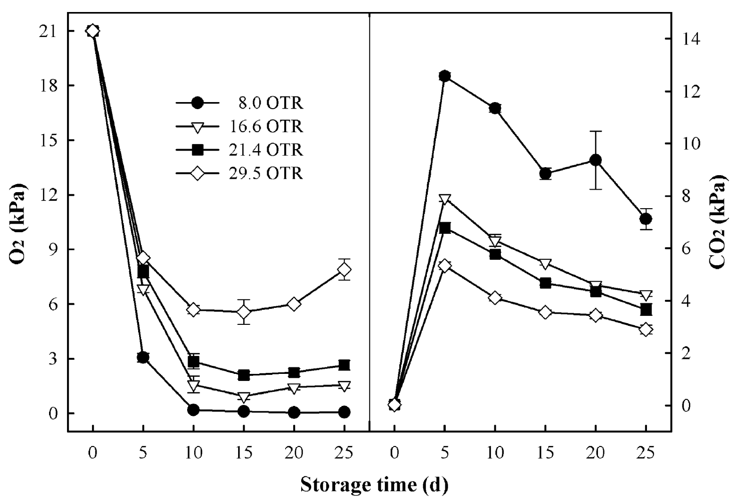

Fig. 2. Gas composition (O_2 and CO_2) of white fresh-cut salad savoy packages prepared with films of selected O_2 transmission rate (OTR) and stored at 5 °C. Vertical bars represent ±1 S.E.

by the total fresh weight of the sample (Loaiza and Cantwell, 1997). Overall quality was evaluated at the end of a 25-days storage period with a 9 point hedonic scale, where 9: like extremely, 7: like moderately, 5: neither like nor dislike, 3: dislike moderately, and 1: dislike extremely (Meilgaard et al., 1991); a score of 6 was considered the limit of salability (Loaiza and Cantwell, 1997; Lopez-Galvez et al., 1997).

2.5. Experimental design and statistical analysis

Product quality and package atmospheres were measured every 5th day during storage with three replications. All quality evaluations were performed in a temperature controlled room at 5° C to minimize the effect of temperature variation during testing. Data were analyzed as a two-factor linear model using the Proc Mixed procedure of SAS (SAS Inst., Cary, NC) with storage time and packaging film as the factors.

3. Results

3.1. Respiration

Respiration rates (CO_2 evolution) of the intact and fresh-cut white salad savoy ranged from 0.8 to 1.1 mmol kg^{-1} per hour and 0.9 to 1.5 mmol kg^{-1} per hour, respectively during 24 h at 5 °C (Fig. 1A). Respiration rates of the intact and fresh-cut violet salad savoy ranged from 0.6 to 0.8 mmol kg^{-1} per hour and 1.1 to 1.4 mmol kg^{-1} per hour, respectively (Fig. 1B). Both white and violet fresh-cut salad savoy had respiration rates higher than intact samples. Additionally, white salad savoy had a higher rate than violet salad savoy.

3.2. Gas composition

The concentration of O_2 and CO_2 in the packages was significantly ($P < 0.05$) affected by the OTRs of the package films for both white and violet salad savoy. In the package atmosphere of both white and violet salad savoy, the O_2 concentration dropped rapidly initially and reached equilibrium on day 10 (Figs. 2 and 3). Carbon dioxide increased rapidly initially and peaked on day 5, followed by a slight decline during the 25 days of storage. For packages prepared with 8.0 OTR films, there was a rapid decrease in O_2 and accumulation of CO_2 with essentially no O_2 (to ~0 kPa) and high CO_2 (up to 11.4–12.6 kPa) levels in the packages starting on day 10 till the end of the storage period. Packages prepared with 16.6 and 21.4 OTR films achieved the desired O_2 (1.4–3.8 kPa) and CO_2 levels (3.6–6.3 kPa) on day 10, and this concentration

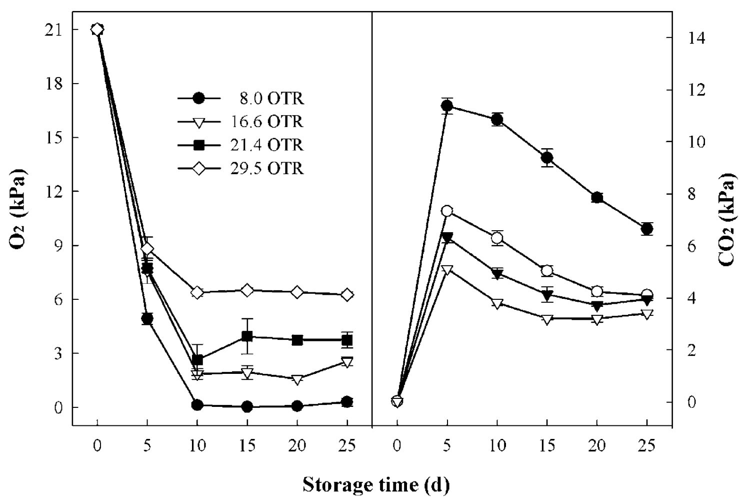

Fig. 3. Gas composition (O_2 and CO_2) of violet fresh-cut salad savoy packages prepared with films of selected O_2 transmission rate (OTR) and stored at 5 °C. Vertical bars represent ±1 S.E.

Table 1
Changes in color of white and violet fresh-cut salad savoy during 5 °C storage

Film OTR	White salad savoy					Violet salad savoy				
	Storage time (days)					Storage time (days)				
	5	10	15	20	25	5	10	15	20	25
	Hue angle									
8.0	98.9	97.8	99.0	95.1	95.3	−27.1	−29.8	−29.7	−29.4	−29.3
16.6	97.0	97.8	95.4	96.4	98.4	−29.0	−30.6	−29.5	−29.0	−29.8
21.4	98.8	99.1	97.9	99.7	96.1	−26.8	−29.3	−27.8	−30.0	−29.1
29.5	97.1	96.3	96.8	98.3	97.0	−27.5	−28.0	−28.6	−28.8	−28.8
	Chroma									
8.0	15.2	14.2	15.4	15.0	14.0	32.9	33.2	34.2	34.8	32.8
16.6	14.4	13.7	13.4	13.7	14.3	29.1	31.5	32.7	33.6	33.1
21.4	14.2	13.2	13.4	14.3	14.7	31.8	32.9	32.1	33.8	30.2
29.5	13.9	14.8	14.1	13.5	13.6	32.3	32.0	30.9	33.2	33.8
	Hue difference									
8.0	0.42	0.15	0.45	0.51	0.45	0.08	1.50	1.44	1.28	1.21
16.6	0.05	0.15	0.40	0.19	0.28	0.96	1.87	1.33	1.04	1.51
21.4	0.39	0.45	0.15	0.61	0.27	0.22	1.22	0.33	1.62	1.01
29.5	0.03	0.24	0.09	0.27	0.04	0.18	0.42	0.74	0.93	0.95

was maintained throughout the 25 days storage period. Atmospheres in the packages with the highest OTR (29.5) film equilibrated at a highest level of O_2 (6.0–7.9 kPa) and lowest levels of CO_2 (2.9–5.3 kPa) among all treatments. In general, the difference in the changes of gas compositions of both white and violet salad savoy was insignificant ($P < 0.05$) during storage except that the depletion of O_2 and accumulation of CO_2 in violet salad savoy was slightly slower than that of white in the corresponding treatments (Figs. 2 and3).

3.3. Color

Hue angle values of white and violet salad savoy ranged 95.1 to 99.7 and −27.1 to −31.6, respectively (Table 1). Changes in hue angle values of both fresh-cut salad savoy were not significantly affected by the OTR of the tested films. Chroma values of white and violet salad savoy were 13.2–15.4 and 29.1–34.8, respectively (Table 1). There was also no significant difference in chroma during storage. The results of hue difference from day 0 to day 25 were within 0.6 and 1.8 for white and violet salad savoy, respectively. Both white and violet samples maintained their inherent leaf color.

Minor discoloration (browning) was observed on cut surfaces of white salad savoy packaged in 16.6 and 21.4 OTR films at the end of storage (Table 2). More intense browning (a score of 2.0 on a 0–4 scale) was noted on samples packaged in 29.5 OTR films, probably due to higher O_2 levels in the packages. Conversely, discoloration was barely detectable on the cut surface of samples packaged in 8.0 OTR film. As a comparison, no cut surface browning was noted on violet salad savoy samples in any of the treatments, except those packaged in 29.5 OTR film.

3.4. Sensorial quality and decay

Off-odor was first detected on white salad savoy samples packaged in 8.0 OTR film after 15 days of

Table 2
Discoloration of packaged fresh-cut salad savoy at the end of 25 days storage at 5 °C

Varieties	Film OTR (pmol s^{-1} m^{-2} Pa^{-1})			
	8.0	16.6	21.4	29.5
White	0.7[a]	1.3	1.3	2.0
Violet	ND	ND	ND	0.7

[a] ND: Not detected, 1: slight, 2: moderate, 3: strong, and 4: severe.

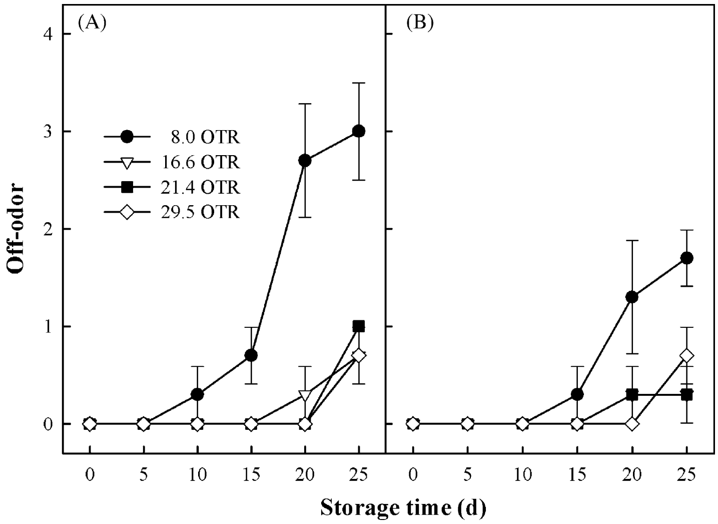

Fig. 4. Off-odor of packaged fresh-cut salad savoy stored at 5 °C: (A) white salad savoy and (B) violet salad savoy. It was scored on a 0–4 scale, where where 0: none; 1: slight; 2: moderate; and 4: severe. Vertical bars represent ±1 S.E.

storage, and the intensity of off-odor increased over time (Fig. 4A). After 25 days storage, there was a very strong off-odor (a score of 3 on a 0–4 scale) on white salad savoy samples packaged in 8.0 OTR film. All other treatments with OTR films ≥16.6 did not develop off-odor until day 20 or 25, and there was only a trace amount of off-odor detected at the end of storage (a score of 0.7–1.0). The development of off-odor on violet salad savoy had a similar trend as white (Fig. 4B), except that the off-odor was not as strong as that on white salad savoy samples packaged with films of corresponding OTRs.

Decay was first observed on white salad savoy samples packaged in 8.0 OTR film and stored for 20 days, with a 2.4% decay noted on those samples at the end of the storage period (Table 3). White salad savoy samples packaged in the highest OTR film (29.5 OTR) also developed decay (1.2%) at the end of the storage period. No decay was noted on white salad savoy samples packaged in all other treatments. Violet salad savoy samples had no decay in any of the treatments.

Table 3
Decay rates (%) of packaged fresh-cut salad savoy at the end of 25 days storage at 5 °C

Varieties	Film OTR ($pmol\,s^{-1}\,m^{-2}\,Pa^{-1}$)			
	8.0	16.6	21.4	29.5
White	2.4	ND[a]	ND	1.2
Violet	ND	ND	ND	ND

[a] ND: Not detected.

In overall quality, samples packaged with 16.6 and 21.4 OTR films maintained freshness with higher quality scores than those packaged in either 8.0 or 29.5 OTR films (Fig. 5). Although both white and violet salad savoy samples showed a similar trend in overall quality scores, violet salad savoy samples had slightly higher scores than white salad savoy samples.

4. Discussion

During the cutting operations used in preparation of fresh-cut produce, rupturing of plant cells induces physiological changes, such as increased rates of respiration and browning (Smyth et al., 1998). Respiration rates of fresh-cuts are generally higher than intact produce (Watada et al., 1996), which agrees with our present study.

Maintaining an optimum atmosphere during storage is effective in delaying quality deterioration (Gorny, 1997; Watada et al., 1996); and optimum atmospheres vary among commodities. As a new vegetable crop, there is no information previously available regarding

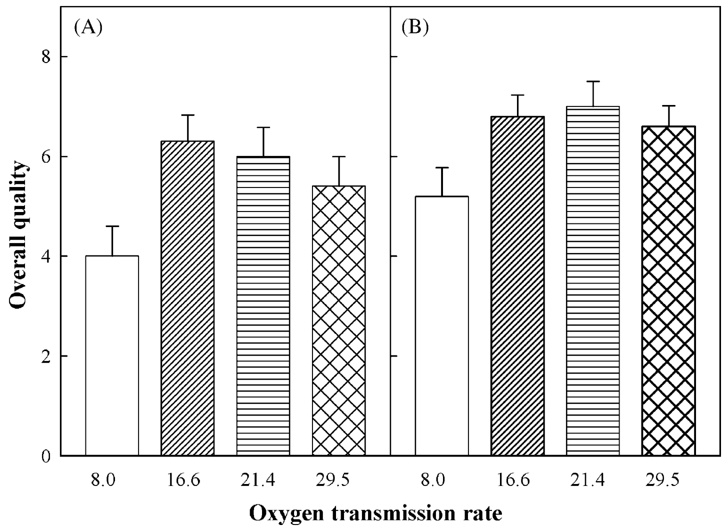

Fig. 5. Overall quality of packaged fresh-cut salad savoy at the end of 25 days storage at 5 °C. Quality was scored on a nine point hedonic scale, where 9: like extremely, 7: like moderately, 5: neither like nor dislike, 3: dislike moderately, and 1: dislike extremely. Vertical bars represent ±1 S.E.

the optimum atmospheres of either intact or fresh-cut salad savoy. Our previous work on storage temperature revealed that salad savoy is not chilling sensitive and must be kept at 0–5 °C for best storage quality (Kim et al., 2003). This optimum storage temperature is similar to that of kale and cabbage, the parent crops of salad savoy. CA studies conducted on cabbage indicate that atmospheres comprise 2–3 kPa O_2 and 3–6 kPa CO_2 appear to be near optimum for cabbage and similar conditions are used for red and savoy cabbage (Gariepy et al., 1985). In our experiments, packages with 16.6 and 21.4 OTR films reached equilibrium at 1.4–3.8 kPa O_2 and 3.6–6.3 kPa CO_2 starting on day 10 storage and maintained these levels throughout storage. Those conditions appear to be near optimum for fresh-cut salad savoy, although minor difference exists between white and violet salad savoy varieties. With the same OTR film, packages containing white salad savoy reached lower O_2 and higher CO_2 equilibrium level than those containing violet salad savoy. This is probably the result of a higher respiration rate seen in white salad savoy than in violet salad savoy. This trend is similar to reported equilibrium atmospheres of several other fresh-cut vegetables (Jacxsens et al., 1999).

Discoloration is another factor that results in quality deterioration of shredded cabbage during storage (Pirovani et al., 1997). The degree of discoloration differs among cultivars (Yano and Saijo, 1987). In the present study, discoloration (browning) on the cut surface was noted on white salad savoy, and the intensity was affected by the O_2 and CO_2 concentrations inside the packages. Samples packaged in the highest OTR film (29.5) developed more severe discoloration than those packaged in the lower OTR film, which might be related to the higher than optimal O_2 (6.0–7.9 kPa) concentrations seen in the packages prepared with higher OTR film. However, the difference in browning intensity between white and violet salad savoy samples was probably due to the combination of package atmospheres and browning potential of different varieties. Further studies on polyphenoloxidase activities and phenolic compounds may be helpful to explain the difference between these two varieties.

Off-odor in packages of fresh-cut products is often an indicator of anaerobic respiration as well as decay under low O_2 and elevated CO_2 levels. There are various reports on off-odor development of fresh-cut products such as fresh-cut broccoli, cauliflower and lettuce etc. (Cameron et al., 1995; Smyth et al., 1998). In the case of salad savoy, samples packaged in all of the tested films had no off-odor development until 20 days in storage, except those packaged in lowest OTR film (8.0 OTR) that contained excessively low O_2 and high CO_2. This treatment also resulted in greater decay at the end of storage.

Overall quality was evaluated to determine if samples were acceptable at the end of storage. Overall quality was influenced by both package atmosphere and variety. Samples packaged in 8.0 OTR film had the lowest quality score due to the development of off-odor and decay, resulting from the depletion of O_2 and accumulation of CO_2. Products in this treatment were considered unacceptable at the end of a 25-day storage. Samples packaged in 16.6 and 21.4 OTR films maintained the best quality with high quality scores during the same storage period under the tested packaging and storage conditions.

5. Conclusion

Film oxygen transmission rates significantly affected package atmospheres and the resulting quality of fresh-cut salad savoy under the tested conditions. With the tested package configuration of 19 cm × 22 cm, product fill weight of 85 g per bag, and 5 °C storage condition, packages prepared with 16.6 and 21.4 OTR films achieved the desired O_2 (1.4–3.8 kPa) and CO_2 (3.6–6.3 kPa) equilibrium levels for both white and violet fresh-cut salad savoy. Products stored in these packages maintained good quality and shelf-life throughout 25 days of storage at 5 °C.

Acknowledgements

We thank Hernando Dominguez for sample preparation, Willard Douglas and Dr. Robert Saftner for their help with film OTR determination. The in-kind support of the raw materials from Salad Savoy Corp. (Salinas, CA) is highly appreciated. Use of a company or product name by USDA does not imply approval or recommendation of the product to the exclusion of others which may also be suitable.

References

ASTM, 1986. Oxygen gas transmission rate through plastic film and sheeting using a coulometric sensor. ASTM procedure # D 3985-81. Annual book of ASTM standards. Section 8: Plastics, Philadelphia, PA. pp. 387–393.

Bell, L., 1996. Sealed package containing respiring perishable produce. US Patent # 430,123.

Cameron, A.C., Talasila, P.C., Joles, D.W., 1995. Predicting film permeability needs for modified atmosphere packaging of lightly processed fruits and vegetables. Hort. Sci. 30 (1), 25–34.

Gariepy, Y., Raghavan, G.S.V., Plasse, R., Theriault, R., Phan, C.T., 1985. Long-term storage of cabbage, celery, and leeks under controlled atmosphere. Acta Hort. 57, 193–201.

Gorny, J.R., 1997. A summary of CA and MA requirements and recommendations for fresh-cut (minimally processed) fruits and vegetables. Gorny, J. (Ed.), Fresh-cut Fruits and Vegetables and MAP, vol. 5. Davis, CA. pp. 30–67.

Guerzoni, M.E., Gianotti, A., Corbo, M.R., Sinigaglia, M., 1996. Shelf-life modeling for fresh-cut vegetables. Postharv. Biol. Technol. 9, 195–207.

Heimadal, H., Kuhn, B.F., Larsen, L.M., 1995. Biochemical changes and sensory quality of shredded and MA-packaged iceberg lettuce. J. Food Sci. 60 (6), 265–1276.

Jacxsens, L., Devlieghere, F., Debevere, J., 1999. Validation of a systematic approach to design equilibrium modified atmosphere packages for fresh-cut produce. Lebensmittel-Wissenschaft und-Technologie 32 (7), 425–432.

Kim, J., Luo, Y., Gross, K.C., 2003. Effect of Storage Temperature on Keeping Quality of Salad Savoy. Proceedings of the 21st International Congress of Refrigeration. Washington, DC CD-ROM.

Loaiza, J., Cantwell, M., 1997. Postharvest physiology and quality of cilantro (*Coriandrum sativum* L.). Hort. Sci. 32 (1), 104–107.

Lopez-Galvez, G., Peiser, G., Nie, X., Cantwell, M., 1997. Quality changes in packaged salad products during storage. Z Lebensm Unters Forsch a 205, 64–72.

Makino, Y., 2001. Selection of packaging conditions for shredded cabbage by genetic algorithms. J. Agric. Eng. Res. 78 (3), 261–271.

Meilgaard, M., Civille, G.V., Carr, B.T., 1991. Sensory evaluation techniques. second ed., CRC Press, Boca Raton, pp. 213–215.

Moyls, L., Hocking, R., Beveridge, T., Timbers, G., 1992. Exponential decay method for determining gas transmission rate of films. Trans. ASAE 35, 1259–1265.

Nunes, M.C., Emond, J.P., 1998. Chlorinated water treatments affect postharvest quality of green bell peppers. J. Food Qual. 22, 353–361.

Pirovani, M.E., Guemes, D.R., Piagentini, A.M., Pentima, J.H.D., 1997. Storage quality of minimally processed cabbage packaged in plastic films. J. Food Qual. 20, 381–389.

Salad savoy Corp., 13 March 2002. <http://www.saladsavoy.com/salad_history.htm>.

Schlimme D.V., Rooney M.L., 1994. Packaging of minimally processed fruits and vegetables. In: Wiley, R.C. (Ed.), Minimally processed refrigerated fruits and vegetables. Chapman and Hall, New York, pp. 156–157.

Sugar, A., 1999. Whole living magazine 1999. 13 March 2002. <http://www.vwgan.com/issue/1999/sep99/greens.htm>.

Smyth, A.B., Song, J., Cameron, A.C., 1998. Modified atmosphere packaged cut iceberg lettuce: effect of temperature and O_2 partial pressure on respiration and quality. J. Agric. Food Chem. 46, 4556–4562.

Watada, A.E., Ko, N.P., Minott, D.A., 1996. Factors affecting quality of fresh-cut horticultural products. Postharv. Biol. Technol. 9, 115–125.

Yano, M., Saijo, R., 1987. New preservation method for shredded cabbage with special reference to non-browning cultivar. J. Jpn. Soc. Cold Preserv. Food 13, 11–13.